EXPERIMENT 10: TORQUES - ROTATIONAL EQUILIBRIUM

PURPOSE:
To get a better understanding of torques

EQUIPMENT:
meter stick, 4 Lever Clamp + fulcrum (for example # P1-1080 arbor) , 3 mass holders, masses (50g ,100g, 300g), unknown mass (unmarked mass in the 200s), scale (up to 300g)

to watch:
https://phet.colorado.edu/en/simulation/balancing-act

DATE______________

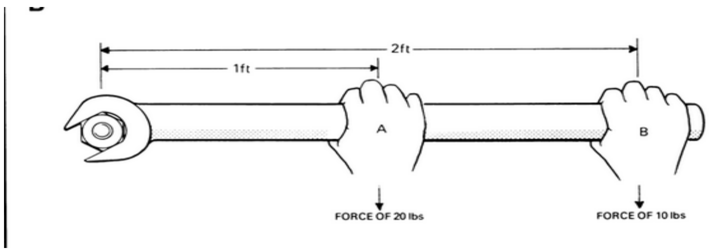
AUTHOR ____

PARTNER _______________________________________

PARTNER _______________________________________

BACKGROUND:

A torque is required to produce rotational motion. A torque is to rotational motion what a push or a pull is to linear motion. **Torque** measures how efficient is a force in producing a rotation.
If the force F is perpendicular to the lever arm r then torque = F x r .



examples:
torque B = 10lbs x 2 ft = 20 lbs ft

torque A = 20lbs x 1ft = 20lbs ft

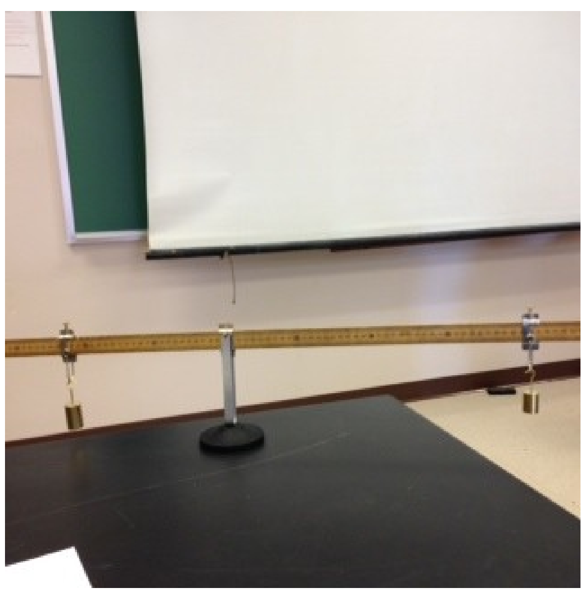
source: http://www.marylandmetrics.com/tech/torqcht2.htm

Newton's law of motion applies to rotational motion as well. But instead of considering force, we consider torque :
1st law : An object not in rotation will continue not to rotate as long as the net torque is zero. Likewise, an object that is rotating uniformly will continue to do so at a constant speed as long as no net torque acts to change the motion (to speed up or slow down the motion).

In this experiment you will study torques that are needed to keep a body that is not rotating from rotating, that is, torques in rotational equilibrium :

equilibrium means : net torque= sum of torques = 0

figure 1



PROCEDURE
Place the meter stick in equilibrium. The fulcrum should be at about the 50cm mark. (see figure 1).
Don't place any of the mass holders yet.

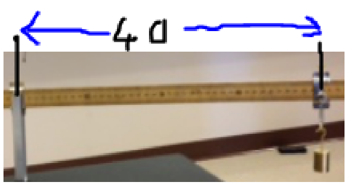
PART 1: Two unequal masses in equilibrium

Note: the unit for torque is N.m but to simplifyy the computation we will use **g.cm** . This is acceptable because mass in g is proportional to the weight of the mass and we are only considering equilibrium.

1) Get 2 mass holders and get 2 weighs marked 50g and 100g. With the digital scale measure the mass of each mass holder. m1 and m2. They are not the same mass:

m1 (holder 1) = ____ g
m2 (holder 2) = _____ g

2) Place 50 g on the mass holder on the right side of the pivot at a distance of **r1= 40cm**.
There is a marker sticking out of the side of the holder. Measure the distances from the marker to the pivot.



M1 = 50g + m1 = _______ g   . M1 produces a **clockwise** torque.

3) Place 100 g on mass holder 2 on the left side of the pivot and adjust its position until static equilibrium is found. M2= 100g + m2 = ________ g

Measure the **distance from pivot** (you should find a number smaller than 25 cm !!)

r2 ________ cm   M2 produces a counter clockwise torque.

4) Compute the clockwise torque T1

T1 = M1 x r1 = ______________ g.cm

compute the counter clockwise torque T2

T2= M2 x r2 = __________ g.cm

5) Since the stick is in equilibrium you should get T1 = T2. If this is not the zase, you did something wrong. Record the percent difference. Record your calculation and comments here .
(% difference = |T1 – T2| / T1)

PART 2: Three unequal masses in equilibrium

1) Get a third mass holder and find its mass. m3 = _____ g. Get a 200g mass.
   The total mass is 200g+m3 = M3 = _______g.

2) Hang the 50g mass (M1) and the 100 g mass (M2) at on the **same side** of the pivot (for example @ right) but at different positions. . Hang a 200g mass (M3) on the opposite side (left) until equilibrium is found. Record the lever arms (distances from pivot) and masses.

M1 = 50g + m1 = ________g   r1' = ____cm (this value is different from r1)

M2 = 100g + m2= _________ g   r2' = ____cm

M3 = 200g + m3 = _________ g   r3 = ____cm

3) Calculate the clockwise torque and the counter clockwise torque :
Tclockwise = M1 x r1' + M2 x r2' = ________ g.cm

Tcounterclockwise = M3 x r3 = _______ g.cm

4) Compare the clockwise and counterclocksie torques and calculate the percent difference.
Show your work. % difference =

PART 3: unknown mass in equilibrium

1) Hang the 100g mass + holder (M2) on one side. Then place the unknown mass M4 of the other side until static equilibrium is found. As shown below.

M2 = ______g

r2" = ________ cm
(distance between pivot and M2)

M4 = ? (to be determined next)

r4 = __________cm
(distance between pivot and M4)

2) By using **clockwise torque = counterclockwise torque** compute the unknown mass M4. Show your work .   (M4 r4 = M2 r2")

M4 = _____________ g = experimental value

3) Use a scale to find the true value of M4true = ________ g.

4) Compare the true value of the mass to the experimental value of the mass by computing the percentage difference. Are you close? They should not differ more than their error.

%difference =

CONCLUSION

1) What is a torque ?

2) Why torques, not just forces, are considered for rotational equilibrium ?

3) Suppose you have 2 masses m1 and m2 on one side of a pivot (at a distance r1 and r2 from the pivot) and you have a mass m4 on the other side (at a distance r4). Write the equation for rotational equilibrium.

3) If the 5N is placed at 20cm from the fulcrum, where is the 3N placed?